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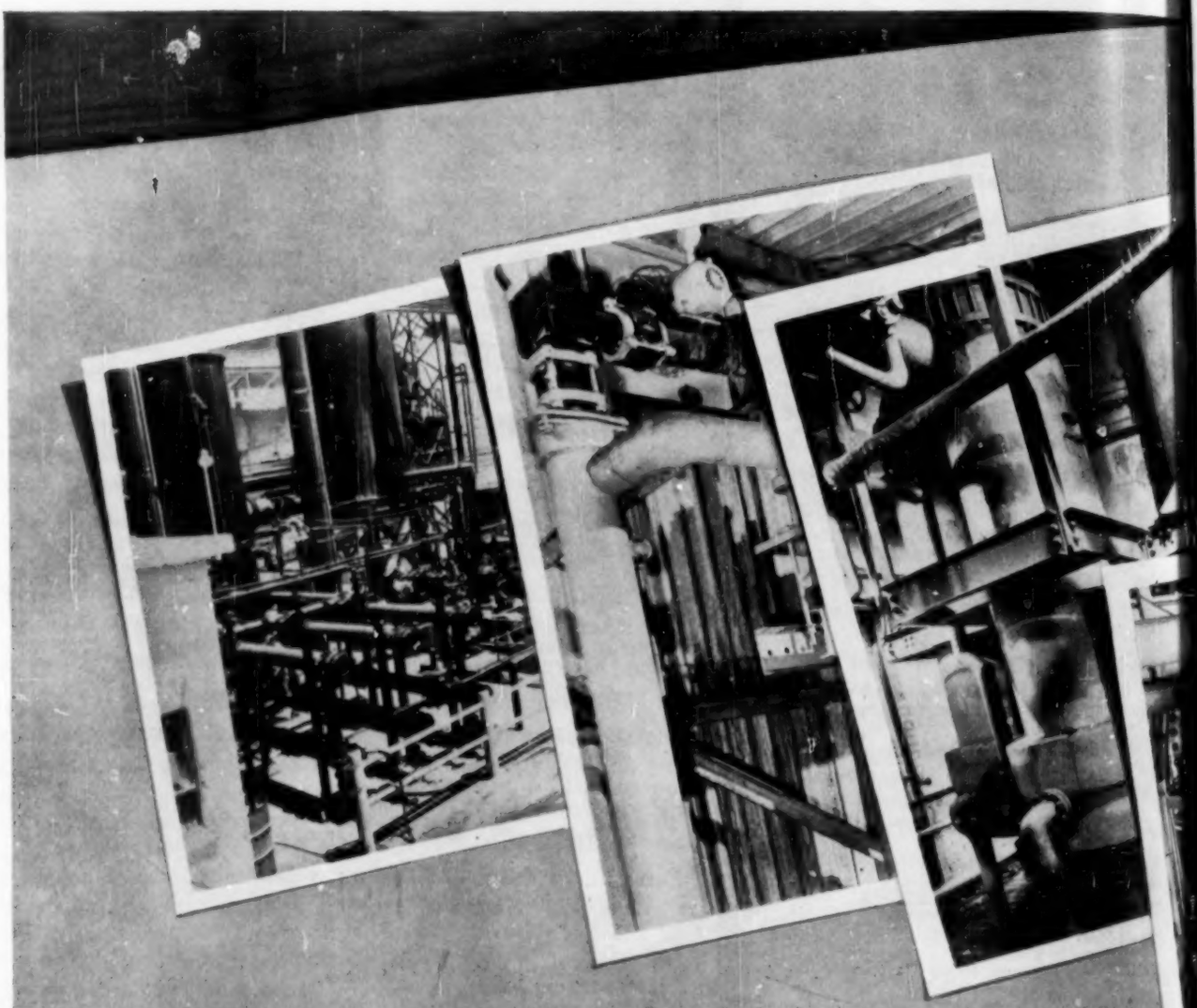

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Editorial

Selective Service and the Graduate Student

IT IS BECOMING increasingly evident that the Selective Service System is not functioning as a system of selective service. In fact, its administrators seem to regard it as a system of Universal Military Training, with the time of induction into the Armed Forces left to the whims of the Local and Appeals Boards. Some science students consequently receive deferments from year to year almost automatically; others are refused deferment and are inducted regardless of the status of their scholastic work.

Many noted scientists and industrialists have publicly expressed dismay at the inroads which are being made on the nation's supply of present and future trained scientific personnel by the draft. Last year at least 2000 graduate science students were inducted. Dr. Howard A. Meyerhoff, Executive Director of the Scientific Manpower Commission, has stated, "Selective Service policy could not do a more effective job of slowing down our technological progress if the policy were devised in the Kremlin." He cites the utter disregard of the best and most disinterested educational judgment and advice. He points out that National Science Foundation fellowships or research assistantships on university contracts with government agencies, such as the A. E. C., O. N. R., O. O. R., are not regarded as reasons for deferment. Incidentally, these agencies will not request deferment for such fellows or assistants for obvious reasons.

Alden H. Emery, Executive Secretary of the American Chemical Society, has written a series of articles protesting the administration of the Selective Service Act. The American Chemical Society in May sent an official protest to Major General Lewis B. Hershey, Selective Service Director, and the A. C. S. Board of Directors voted that its attitude be publicized among members of Congress and government administrators.

Only a very small number of graduate students would wish to use their status to secure permanent deferment if they were vitally needed in the Armed Services. However, it is quite probable at the present time that the country's needs would be served best if many science students were *required* to continue to a higher degree and then go into professional work, as their contribution to Selective Service. The country is in a period of scientific expansion, which

(*Continued on next page*)

is necessary to satisfy civilian needs and at the same time maintain increased peacetime defense and prepare for possible military emergency. An increasing need for engineers, chemists, and physicists is anticipated. The total number of college students has recently decreased, simply because fewer babies were born 18 to 22 years ago. Further, the *percentage* of students majoring in physical sciences and continuing with graduate studies has decreased. Perhaps these deficiencies will be corrected during the coming decade, but in the meantime there will be lean years.

The Selective Service System apparently is suffering from a lack of uniform policy in individual cases and localities, and from a lack of wise and far-seeing, vigorous top directional policy. Local Boards cannot all have the same viewpoints, and other pressures are at work. At the very least, Local Boards could be required to interrupt a student's scholastic career only at some convenient milestone such as the attainment of a degree; it is certainly unfair to allow him to start Ph.D. work, then reclassify him when he is halfway toward the goal. It is not satisfactory to give him two more months to finish his crucial experiments, then send him to camp with notebook in hand, hoping to write the thesis after hours. But the *least* is not enough; a re-examination at the very top level, of the whole Selective Service policy, is strongly indicated by the statements of numerous outstanding men. The President and his advisory staff should look into this situation very carefully.

The Electrochemical Society has made no public appeal or official protest in this matter. Its Directors have reviewed the situation and some of its officers and prominent members have expressed their dismay. We believe the Society should join other scientific and engineering organizations in insisting that steps be taken immediately to insure a more intelligent administration of the Selective Service System. There was never a time when the proper training and use of our potential scientific manpower was more vital to our national safety!

—CVK

found in the cell. This does not occur in neutral or acid solutions.

Absence of an appreciable temperature coefficient also indicates that there is no decomposition in neutral or acid solutions. For the difference between production and decomposition of stibine to be independent of temperature when the rate of removal of undecomposed stibine from the cell is constant, as in this case, rate of decomposition must be equal to rate of formation, as can be shown mathematically. This means, however, that no stibine would be detected in the bubbler. Therefore, there should be no stibine decomposition in solutions in which there is no appreciable temperature coefficient of stibine detection.

Absence of a temperature effect must then be explained on the basis of the rate of production being relatively temperature independent. The likely reason is that the production rate obeys an equation similar to Tafel's equation for hydrogen overvoltages, such as:

$$d(\text{stib.})/dt = k \exp - (F^* + \alpha\eta f)/RT$$

In this equation, F^* is the activation energy required and η is the overvoltage, T is absolute temperature, f is the faraday, and α is a constant. As the temperature is increased from 25° to 35°C, the overvoltage (of hydrogen since it is being evolved) decreases by about 8%. If this decrease compensates for the temperature increase (η is negative), the rate would be temperature independent. In retrospect, it is unfortunate that temperature coefficients were not determined for alkaline solutions, where decomposition was observed to occur.

Loss of stibine in the alkaline solutions would then come about by reaction between the stibine and alkali, and not by thermal decomposition. Low rates and visible precipitate show that this attack is rapid. The fact, however, that stibine did not decompose in bubbling it through N/10 NaOH indicates that the solution immediately adjacent to the cathode would have to be very strongly alkaline. The apparent falling off in rate observed in neutral unbuffered solutions at high current densities seems to be due to increased hydroxyl ion concentrations in the vicinity of the cathode.

The mechanism of formation of stibine is not likely to be by the direct union of three hydrogen atoms and an antimony atom, but probably by electrochemical reduction of either a water molecule or a hydronium ion.

For the rate-determining step to be a combination of neutral atoms, the reaction rate would be independent of potential but dependent on current, i.e., hydrogen atom concentration, since the amount of stibine produced is negligible in comparison to the hydrogen evolved. Neither of these conditions is fulfilled. In acid and buffered solutions, rates are not the same at equal current densities, and it has been observed that anything which increases the potential (decreased current density, high overvoltage impurities, contact with a mercury cathode) also increases the rate of stibine evolution. If the rate-determining step were combination, it could be expressed as:

$$r = k\,\mathrm{H}^n \qquad \text{(I)}$$

where r is the rate, k is the specific rate constant, H is the concentration of hydrogen atoms, and n is an integer, either 1, 2, or more probably 3. Since stibine evolution is negligible in comparison with that of hydrogen, using Tafel's equation,

$$i = k'\mathrm{H}^2 \qquad \text{(II)}$$

Combining these two gives:

$$r = k''i^{n/2} \qquad \text{(III)}$$

Experimental results do not fit this type of equation.

The potential dependence of stibine formation indicates the electrochemical reduction of either water or hydronium ion. Attempts made to measure potentials to correlate with rates were, however, useless, due to indeterminate IR drops at high current densities and low concentrations.

From the decrease in rate at high acidities, coupled with the stability of stibine in acid, it appears either that hydronium ion is not discharged in the course of this reaction or that its discharge takes place at potentials too low for the formation of stibine. Consequently, it is presumed stibine is formed by water discharge, because the latter occurs at high potentials. This opinion is supported by Fig. 2, which shows higher rates at higher water activities. The rate equation for stibine is therefore probably

$$r = k\mathrm{H}^2 \exp - \alpha\eta F/RT \qquad \text{(IV)}$$

or

$$r = k\mathrm{H}_2 \exp - \alpha\eta F/RT \qquad \text{(V)}$$

depending on whether the reaction requires two adsorbed atoms or an adsorbed molecule. Here, α is the fraction of the overvoltage which operates between the initial and the activated states.

The results do not agree with those of Sand and coworkers (3, 4). However, the inability of Sand, Grant, and Lloyd (3) to duplicate the work of Sand, Weeks, and Worrel (4), plus their use of a porous

porcelain pot as a cell and their use of rubber and cement, suggests that both their results are incorrect, probably due to the presence of impurities. Also, the use of a gravimetric technique requiring two weighings of each of three absorption tubes, to determine quantities which were reported to be at most about 20 mg is not conducive to accuracy.

Conclusions

Stibine is formed at antimony cathodes in very small amounts increasing with increasing current densities up to at least 500 milliamp/cm^2. Stibine is formed from adsorbed hydrogen and water. The reaction depends upon voltage to a considerable extent. Increased acidity lowers the rate of stibine evolution, probably through decreasing the voltage at the cathode. This indicates that water discharge is associated with higher cathode voltages and, therefore, with high hydrogen overvoltages.

Any discussion of this paper will appear in a Discussion Section to be published in the June 1955 issue of the Journal.

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4. H. J. S. Sand, J. Grant, and W. V. Lloyd, *ibid.*, **1927**, 378.

Current Affairs

News Notes in the Electrochemical Field

"Modern Electroplating" a Must

"Modern Electroplating" has been selected as one of the 1953–1954 season's most essential books by R. R. Hawkins, Chief of the New York Public Library's Science and Technology Division.

Every year Mr. Hawkins chooses 100 books in science and technology which he considers essential to technical sections of public libraries. The list is published in the technical book edition of the *Library Journal*, and this year John Wiley & Sons, Inc., publisher of "Modern Electroplating," was the leader with 20 titles.

Enthone Announces Distributors

Enthone, Inc., New Haven, Conn., announces the appointment of Austin F. Fletcher, Inc., Binghamton, N. Y., as exclusive distributor for Enthone products and processes in the upper New York State and northeastern Pennsylvania area. Enthone chemicals will be stocked in the Austin F. Fletcher, Inc., warehouse and shipment to customers in the area will be made F.O.B. Binghamton.

Weaver Engineering and Supply Company, Inc., Grand Prairie, Texas (Dallas), has been announced as stock point distributor for Enthone's complete line of chemicals for the metal finishing industry. Stocks of Enthone products will be maintained at the Grand Prairie location for shipment to concerns in Texas, Oklahoma, Arkansas, and Louisiana.

Olin Industries and Mathieson Chemical Merger

Stockholders of Olin Industries, Inc., and Mathieson Chemical Corporation have voted to approve the merger of the two companies to form a new corporation, Olin Mathieson Chemical Corporation. The new company will be one of the nation's important diversified processing and manufacturing enterprises.

Olin Mathieson products will include industrial and agricultural chemicals, petrochemicals, "Squibb" pharmaceuticals, "Winchester" sporting firearms, "Western" and "Winchester" sporting ammunition, cellophane, polyethylene film, industrial explosives, nonferrous alloys and fabricated metals parts, "Ecusta" fine specialty papers, "Frost" forest products, "Powell" insecticides, "Ramset" powder-actuated tools and fasteners, and electrical products.

AES Research Committee

Earl J. Serfass, head of the Lehigh University Chemistry Department, Bethlehem, Pa., has been re-elected chairman of the Research Committee of the American Electroplaters' Society. A recognized authority in the fields of chemistry, electroplating, and metal finishing, Dr. Serfass is responsible for close to a dozen AES research projects being carried out in various universities, research foundations, and private industry in the United States and Canada. His committee comprises 10 top men in the field with close to 100 additional members of the American Electroplaters' Society representing more than 140 large, medium, and small corporations and several government agencies.

Other ECS members elected to the Research Committee include: Leslie C. Borchert, Houdaille-Hershey Corporation, Detroit, Mich.; Myron B. Diggin, Hanson-Van Winkle-Munning Company, Matawan, N. J.; Lloyd O. Gilbert, Rock Island Arsenal, Ill.; Edwin R. Bowerman, Jr., Sylvania Electric Products Inc., Long Island, N. Y.; Arthur H. DuRose, Harshaw Chemical Company, Detroit, Mich.; Edward A. Parker, Technic, Inc., Providence, R. I.; and William Blum, Washington, D. C.

Acheson Colloids Opens New Office

Acheson Colloids Company, Port Huron, Mich., division of Acheson Industries, Inc., has announced the opening of a Rochester sales headquarters. Mr. E. A. Lampman, Service Engineer, is territorial sales supervisor for western New York and western Pennsylvania, and will be in charge. The new office is located at 545 Powers Building, Rochester, N. Y.

Electronic Thickness Gauges Developed

The National Bureau of Standards, Washington, D. C., recently developed three types of instruments for measuring the thickness of electrodeposited coatings. While all three instruments depend upon the difference in electrical conductivity between the plating and the basis metal, each makes use of different methods for sensing specimen resistance. Two of the instruments, the "Dermitron" and the Phase-Angle Thickness Meter, utilize electromagnetic coupling to the specimen, making use of the reflected field from eddy currents induced in the specimen. A third, a waveguide inspection tool, employs direct conductivity measurement with point electrode. All three devices permit simple nondestructive determination of plating thickness of sample thickness for homogeneous metals. When appropriately calibrated, they can be used for measurement of magnetic as well as nonmagnetic materials.

NACE Publications Available

Two new publications are available from the National Association of Corrosion Engineers, 1061 M & M Building, Houston 2, Texas.

The first is a 346-page book containing 3512 abstracts of articles and books on corrosion. The articles are from more than 500 periodicals published all over the world and are abstracted by some 30 agencies that authorize NACE to use their abstracts. This third volume of abstracts published by NACE contains summaries of articles and books published in 1948–1949, topically indexed and cross indexed, and with both alphabetical subject and author indexes. The two previous volumes covered articles published in 1945 and 1946–1947.

The second publication is a technical

report entitled "Some Observations of Cathodic Protection Criteria in Localized Pitting" by L. P. Sudrabin, chairman of NACE Technical Committee T-26 on Minimum Current Requirements for Cathodic Protection. Observed potential measurements of protective current applied to a model cell including basic spatial, electrical, and environment factors found in localized pitting are detailed in the report. Conclusions based on observations are included.

New Standards Approved at ASTM Annual Meeting

The 1954 Annual Meeting of the American Society for Testing Materials, held throughout the week of June 13 at Chicago, featured 36 technical sessions at which were presented 110 technical papers covering various aspects of engineering materials, and also included 600 meetings of the technical committees.

Seventy-two of the society's technical committees reported at the meeting, with the result that 65 new specifications and tests were approved and revisions in 229 existing tentatives and standards were acted on. A total of 109 specifications and tests that had been published previously as tentative were approved for reference to ASTM letter ballot for adoption as standard. All of these new and revised standards will be published later in the year in the 1954 Supplement to the "Book of ASTM Standards." Including the 1954 Annual Meeting actions, there are now about 2120 ASTM Standards.

Titanium Alloy Replacement for Steel

A light-weight titanium alloy considered suitable as a replacement for steel in military weapons has been developed for the Ordnance Corps by the Armour Research Foundation of Illinois Institute of Technology, Chicago. The alloy was developed during the course of a program being sponsored at the Foundation by the Watertown Arsenal Laboratory, Watertown, Mass.

It has been revealed that the titanium alloy is 40% lighter in weight than high-strength steel. The Watertown tests also show that the alloy is highly corrosion-resistant and has properties which compare favorably with those of steel used in manufacturing weapons. Further tests must be made to assure that the alloy is as good as first tests indicate, but the alloy is considered as a potential substitute for steel in many ordnance components. Armour Research Foundation, which has been conducting titanium research for five years, is continuing its work in the program which resulted in the new alloy.

Yardney Silvercels Power K2 Expedition Radio

According to a cable received from the Yardney-affiliated Laboratories in Italy, the radios in the Italian K2 expedition to Karakorum were powered by Yardney Silvercel (silver-zinc) batteries (Registered U. S. Patent Office), contributed to the expedition by these Italian Laboratories.

This new proof of reliable performance at high altitudes and under adverse climatic conditions points out the exceptional suitability of the Yardney Silvercel to any application where dependability, ruggedness, and outstanding performance are vital. The remarkable weight and space savings, plus the high output and constant voltage of the batteries, have made an important contribution to the success of this mountaineering expedition, as well as to many defense and civilian projects.

G. E. Forms Two New Departments

Two new General Electric Company organizations, a Meter Department and an Instrument Department, have been formed. An additional step in the company's decentralization program, the move divides the former Meter and Instrument Department into two separate units. The Meter Department will make its headquarters at Somersworth, N. H., while the Instrument Department will remain in Lynn, Mass.

Dow Chemical Expands

The Dow Chemical Company has announced the opening of a new field office in Cincinnati to serve customers in southern Ohio, southeastern Indiana, and sections of Kentucky and West Virginia. The office will handle all Dow product categories, including industrial and fine chemicals, plastics, magnesium, and agricultural chemicals.

Continuing to expand its activities abroad, Dow has purchased a half interest in Pyrina, S. A., of Mexico, which is engaged in the manufacture of basic pharmaceutical products for the Mexican market.

Simultaneously, Dow Chemical International Limited, a Dow export subsidiary, announces the establishment of a new sales office in Mexico City, which will serve not only Mexico but also Central American countries, as well as Colombia, Venezuela, British Guiana, Surinam, French Guiana, and the West Indies.

SECTION NEWS

India Section

The Annual Meeting of the India Section was held on Tuesday, June 29, with Professor M. S. Thacker, Chairman of the Section, presiding.

At the commencement of the meeting Professor Thacker read the letter received by him from Dr. Marvin J. Udy, newly-elected President of The Electrochemical Society, wherein the President-elect sent his greetings and good wishes for further progress of the Section and wrote appreciatively of the *Bulletin* and the activities of the Section, and the reply sent by him reciprocating the kind sentiments expressed by Dr. Udy.

The minutes of the Business Meeting held on May 14 were confirmed.

The Secretary-Treasurer then presented the Fourth Annual Report of the Section covering activities during 1953–1954, indicating a steady progress in the Section's activities.

The next item on the agenda, relating to the election of officers for 1954–1955, was taken up. The Secretary informed the members present that Dr. T. L. Rama Char, the nominee for the Chairmanship, was anxious that Professor Thacker should continue as Chairman for at least another year. Members present agreed with Dr. Rama Char's suggestion and requested Professor Thacker to accept the Chairmanship for the year. Professor Thacker was kind enough to accede to the request of the members present.

The rest of the nominations of the nominating committee were adopted. The Chairman then announced the following members as having been elected Officers of the Section for 1954–1955:

Chairman—M. S. Thacker
Vice-Chairman—S. Ramaswamy
Vice-Chairman—B. Narayan Das
Secretary-Treasurer—S. Krishnamurthy
Representatives on Council of Local Sections:
L. Charat Ram and K. Rajagopal

The membership dues of the Section for 1955 were fixed at Rs.2/8/-.

The following were then nominated members of the various committees for the year 1954–1955.—*Membership Committee:* B. K. R. Prasad and K. Rajagopal. *Bulletin Editorial Committee:* T. L. Rama Char, Chairman; V. Aravamuthan; B. K. R. Prasad; J. Balachandra, Editor; and M. S. Thacker, S. Ramaswamy, B. Narayan Das, and S. Krishnamurthy, Ex-Officios. *Bulletin Advisory Board:* R. S. Ramachandran, K. Seshadri, K. Rajagopal, A. Joga Rao, L. C. Jariwala, P. S. Narayana, R. Thyagarajan, and V. M. Dokras.

With a vote of thanks to the Chair, the meeting came to a close.

S. KRISHNAMURTHY,
Secretary-Treasurer

The papers presented at the India Section symposium on "Electroprocess Industries" held during November 1953 [announced in *J. Electrochem. Soc.*, 101, 80C (1954)] have been published in the *Bulletin of the India Section*, ECS, Vol. 3, No. 2 (1954).

T. L. RAMA CHAR
Regional Editor, India

BOOK REVIEWS

TITANIUM AND TITANIUM ALLOYS, by John L. Everhart. Published by Reinhold Publishing Corporation, New York, 1954. 184 pages, $3.00.

This readable little book, page size 4 in. x 6½ in., aims to give the reader a selective review of the hundreds of papers dealing with titanium and titanium alloys that have appeared in the recent literature. The book is slanted primarily at the engineer or designer interested in the possibilities of applying titanium to the solution of his problem. The book deals almost exclusively with technology and is divided into ten chapters: 1. Introduction; 2. High Purity Titanium; 3. Properties of Commercial Titanium; 4. Properties of Commercial Titanium Alloys; 5. Heat Treatment; 6. Forming and Fabricating; 7. Joining; 8. Machining and Grinding; 9. Cleaning and Finishing; 10. Applications. At the end of each chapter pertinent references are given. The typography of the book is good.

The reviewer thinks that the appearance of this brochure at this time is opportune and that it will be welcomed by persons of widely different interests in the Cinderella metal.

E. E. SCHUMACHER

THE INSULATION OF ELECTRICAL EQUIPMENT. Edited by Willis Jackson. Published by John Wiley & Sons, Inc., New York, 1954. 336 pages, $7.75.

This is a very good textbook for the engineer or scientist who has an interest in electrical insulation. The editor and contributors are authorities in the field. There are several chapters on the fundamental nature and requirements of electrical insulation which, though brief, present the basis upon which research and development are founded. The sections on application of insulation include both power and communication equipment. These sections are confined to British practice. However, practices and developments here and abroad in this field seem to be sufficiently similar so that the value of these chapters to the American engineer is not materially altered.

W. MCMAHON

MEETINGS OF OTHER ORGANIZATIONS

10th ANNUAL NATIONAL ELECTRONICS CONFERENCE, Hotel Sherman, Chicago, Oct. 4–6. For information write: Karl Kramer, Executive Secretary, 852 E. 83rd St., Chicago 19, Ill.

ARMOUR RESEARCH FOUNDATION OF ILLINOIS INSTITUTE OF TECHNOLOGY will hold a symposium on light microscopy on Oct. 11–13, followed by a symposium on electron microscopy sponsored by the Electron Microscope Society of America on Oct. 14–16, at the Moraine Hotel, Highland Park, Ill. Sessions are scheduled in photomicrography, ultraviolet and infrared microscopy, fusion methods in analysis, phase microscopy, and x-ray and ion microscopy.

AMERICAN CHEMICAL SOCIETY, Chicago Section, 8th National Chemical Exposition, Colosseum, Chicago, Oct. 12–15. For information Write: A. T. Winstead, 1155 16th St., N.W., Washington 6, D. C.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, South Central Region Conference, Adolphus Hotel, Dallas, Oct. 14–15. For information write H. L. Bilhartz, Regional Chairman, P. O. Box 2819, Dallas, Texas.

TWELFTH ANNUAL PITTSBURGH DIFFRACTION CONFERENCE, Mellon Institute, Pittsburgh, Pa., Nov. 3–5; joint meeting with the American Crystallographic Association. For a copy of the preliminary program when available, write to Dr. P. K. Koh, Allegheny Ludlum Research Laboratories, Alabama Avenue, Brachenridge, Pa.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, Fourth Annual Conference of Western Region, Hotel Biltmore, Los Angeles, Nov. 18–19. The conference will follow a 3-day NACE-sponsored short course at the University of California at Los Angeles.

THIRD SALON DE LA CHIMIE ET DES MATIÈRES PLASTIQUES, Paris, Dec. 3–12.

TULSA SECTION, NATIONAL ASSOCIATION OF CORROSION ENGINEERS, Sixth Annual Corrosion Short Course for Pipeliners, Mayo Hotel, Feb. 16–18, 1955.

SOCIÉTÉ DE CHIMIE PHYSIQUE, Paris, May 31–June 3, 1955. Theme of meeting will be Chemical Actions of Ionizing Radiations on Liquids. Titles of papers to be presented should be received by Dec. 15 and manuscripts submitted before Feb. 28, 1955, so that copies can be distributed in advance. For information write: G. Emschwiller, Ecole Superieure de Physique et de Chimie, 10, rue Vauquelin, Paris V^{e}, France.

PERSONALS

S. RAMASWAMY has returned to India after a four-month tour in Germany. He visited alkali-chlorine and other electrolytic plants in connection with the development plans of the Mettur Chemical and Industrial Corporation, Mettur Dam.

J. BALACHANDRA, of India, left for the United States in September for advanced technical training in the University of Wisconsin, Madison, under the Technical Cooperation Mission of the U. S. A.

M. S. THACKER, of the Indian Institute of Science, Bangalore, recently returned to India after a six-week tour in France, England, Germany, and Switzerland. He attended three meetings in France: Research Committee, UNESCO; Committee, International Electrotechnical Commission; and Conference Internationale des Grands Resaux Electriques, of which he is the Chairman of the Indian National Committee. He has proceeded to Rio de Janeiro, Brazil, for the World Power Conference, where he will represent the Government of India and the UNESCO and will be the leader of the Indian Delegation.

S. KRISHNAMURTHY has been designated Chief Chemist, Indian Telephone Industries Ltd., Bangalore.

N. B. SHIVARAMAN, formerly with M/s Tata Chemicals, Mithapur, has been appointed as Probationery Executive Trainee in M/s Burmah-Shell Refineries, Bombay. He is now in England undergoing training in the Burmah-Shell Refineries at Shell Haven, Essex.

B. NARAYAN DAS, formerly with the University of Bombay, has joined the Delhi Polytechnic, Government of India, Delhi, as Head of the Department of Applied Science.

T. L. RAMA CHAR left for the United States in September for advanced technical training in the Illinois Institute of Technology, Chicago, under the Technical Cooperation Mission of the U. S. A.

ROBERT S. ARIES, New York consulting engineer and Adjunct Professor of Chemical Engineering at the Polytechnic Institute of Brooklyn, was the appointed American Delegate to the convention of the Pan American Federation of Engineering Societies in Sao Paulo, Brazil, August 2–6. Dr. Aries represented the American Society of Mechanical Engineers and was also a delegate of the Engineering Joint Council.

JOHN REHNER, JR., research chemist in the Esso Laboratories of the Standard Oil Development Company, Linden, N. J., served as chairman of the Section on Elastomers at the Gordon Research Conference held August 2–6 at Colby College, New London, N. H. Dr. Rehner was in charge of organizing the program and arranging for speakers, and served as moderator during the presentation of papers pertaining to synthetic rubbers and other elastic-type materials.

PETER J. LUCCHESI has been appointed chemistry instructor at the Illinois Institute of Technology, Chicago. He was formerly an instructor at New York University and Adelphi College.

R. NICHOLS HAZELWOOD, on a leave of absence from his position as Research Chemist with the Line Material Company, South Milwaukee, Wis., is studying for a Ph.D. at the Donner Laboratory, University of California, Berkeley, on a National Science Foundation Fellowship.

LETTER TO THE EDITOR

The Oxidation Free Energy per Faraday of an Electrode

Dear Sir:

The recent note by W. M. Latimer[1] in reply to a criticism by J. O'M. Bockris[2] points up again the unfortunate misunderstanding which divides the world of chemists on the choice of sign of the electrode potentials. Latimer correctly states that, given the spontaneous cell reaction

$$Zn + 2H^+ = Zn^{++} + H_2 \qquad (I)$$

to which the positive potential value $E^\circ = +0.76$ v is assigned, in conformity with the thermodynamic equation

$$\Delta F^\circ = -nFE^\circ \qquad (II)$$

there is only one choice possible for the potential E° of the half reaction

$$Zn = Zn^{++} + 2e^- \quad E^\circ = +0.76 \text{ v} \qquad (III)$$

if the choice is made

$$2e^- + 2H^+ = H_2 \quad E^\circ = 0.00 \text{ v} \qquad (IV)$$

We then also have

$$Zn^{++} + 2e^- = Zn \quad E^\circ = -0.76 \text{ v} \qquad (V)$$

Latimer[1] does not bring out the experimental fact that zinc is the negative terminal of a standard zinc-hydrogen cell. Suppose such a cell connected by two leads of the same kind of metal to,[3] and in balance with, a potentiometer. The electrical potential within the lead connected to the zinc electrode is -0.76 v if the value 0.00 v is assigned to the electrical potential of the lead connected to the hydrogen electrode. The potentiometer can be thrown out of balance by an infinitesimal amount, and an infinitesimal current caused to flow in the direction of reaction (III) or of reaction (V), without altering the electrical potential of the lead connected to the zinc electrode by more than an infinitesimal amount from the value -0.76 v.

The above experimental fact accounts for the practice followed by the school represented by J. O'M. Bockris[2] of assigning the value -0.76 v to the standard potential of the zinc electrode regardless of the direction in which an infinitesimal current flows. The two conventions use the term potential in a different sense, as pointed out by J. J. Lingane.[4]

A reconciliation between these two conflicting points of view is possible, without sacrificing the well established thermodynamic conventions of G. N. Lewis and M. Randall,[5] by emphasizing the concept introduced by these authors of *the free energy of an electrode reaction (per equivalent)*. For the standard zinc electrode, this reaction is

$$\tfrac{1}{2}Zn = \tfrac{1}{2}Zn^{++} + e^- \qquad (VI)$$

The free energy change of reaction (VI) is

$$\Delta F^\circ = (-1)\mathbf{F}(+0.76 \text{ v}) = -0.76 \text{ Faraday v}$$

and the *standard oxidation free energy per Faraday* of the zinc electrode is

$$\Delta F^\circ/n\mathbf{F} = -0.76 \text{ v} \qquad (VII)$$

a number which agrees in magnitude and in sign with the electrical potential of the lead connected to the zinc electrode when the standard zinc-hydrogen cell is in balance with a potentiometer, and the value 0.00 v is assigned to the potential of another lead of the same

[1] W. M. LATIMER, *J. Am. Chem. Soc.*, **76**, 1200 (1954).

[2] J. O'M. BOCKRIS, *Trans. Faraday Soc.*, **49**, 1506 (1953).

[3] J. WILLARD GIBBS, "The Collected Works of J. Willard Gibbs, Volume I, Thermodynamics," pp. 332 and 429, Longmans Green & Co., New York (1928).

[4] J. J. LINGANE, "Electroanalytical Chemistry," pp. 32ff, 181ff, Interscience Publishers, Inc., New York (1953).

[5] G. N. LEWIS AND M. RANDALL, "Thermodynamics," McGraw-Hill Book Co., Inc., New York (1923).

kind of metal[3] connected to the hydrogen electrode.

In Table I, I have copied Table VII on page 434 of Lewis and Randall's work, with the addition of one single column, in which the values given by

TABLE I. *Free energy of electrode reactions at 25°C (per equivalent)*

Reaction	$\Delta F°_{298}$ cal/equiv	$\Delta F°_{298}$ volts
$Li = Li^+ + e^-$	−68248	−2.9578
$Rb = Rb^+ + e^-$	−67473	−2.9242
$K = K^+ + e^-$	−67431	−2.9224
$Na = Na^+ + e^-$	−62588	−2.7125
$\frac{1}{2}$ Zn = $\frac{1}{2}$ $Zn^{++} + e^-$	−17492	−0.7581
$\frac{1}{2}$ Fe = $\frac{1}{2}$ $Fe^{++} + e^-$	−10175	−0.4410
$\frac{1}{2}$ Cd = $\frac{1}{2}$ $Cd^{++} + e^-$	−9174	−0.3976
$Tl = Tl^+ + e^-$	−7760	−0.3363
$\frac{1}{2}$ Sn = $\frac{1}{2}$ $Sn^{++} + e^-$	−3138	−0.1360
$\frac{1}{2}$ Pb = $\frac{1}{2}$ $Pb^{++} + e^-$	−2815	−0.1220
$\frac{1}{3}$ Fe = $\frac{1}{3}$ $Fe^{+++} + e^-$	−1040	−0.0451
$\frac{1}{2}$ $H_2 = H^+ + e^-$	0	0.0000
$\frac{1}{2}$ Cu = $\frac{1}{2}$ $Cu^{++} + e^-$	7956	0.3448
$Hg = \frac{1}{2}$ $Hg_2^{++} + e^-$	18427	0.7986
$Ag = Ag^+ + e^-$	18444	0.7993
$\frac{1}{2}$ $S^{--} = \frac{1}{2}$ S (rhomb.) + e^-	−11700	−0.507
$OH^- = \frac{1}{4}$ $O_2 + \frac{1}{2}$ $H_2O + e^-$	9175	0.3976
$I^- = \frac{1}{2}$ $I_2(s) + e^-$	12361	0.5357
$Br^- = \frac{1}{2}$ $Br_2(l) + e^-$	24595	1.0659
$Cl^- = \frac{1}{2}$ $Cl_2(g) + e^-$	31367	1.3594

these authors in *calories per equivalent* are converted to *Faraday-volts per Faraday*, or simply to *volts*. [The conversion factor used, 23074 calories = 1 Faraday-volt, is the one accepted by Lewis and Randall, and differs slightly from the best modern values: 23063 (chemical scale of atomic weights), 23069 (physical scale)[6].] The values quoted in Table I are taken from Lewis and Randall without modification and may differ somewhat from those accepted today.[7]

These examples suffice to show that a tabulation of *standard oxidation free energies per Faraday* of the electrodes, as prepared by Lewis and Randall, yields a series of values in volts that would satisfy the school of J. O'M. Bockris.

ANDRÉ J. DEBÉTHUNE
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Chestnut Hill, Mass.

[6] J. W. M. DUMOND AND E. R. COHEN, *Rev. Mod. Physics*, **20**, 106 (1948).

[7] W. M. LATIMER, "Oxidation Potentials," Prentice Hall, Inc., New York (1952).

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